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Technical State of 868-870 MHz Radio Modules in the SRD Band

1 Introduction

Wireless detection systems are becoming more and more the norm in modern building technologies. Their competitive advantages are their cost-efficiency and flexibility with which the system parameters can be set and the detector zones be configured. Due to the fact that they have to compete with wired (conventional) systems they need the same standard of safety and reliability. This and other economical aspects are challenging the development of today's wireless detection systems.

2 Attenuation of RF-transmission calculation

The attenuation factors inside a building are an important factor for safe planning and running of the system because radio transmission is limited in range. Mistakes which are made in early project stages lead, without fail, to much customer dissatisfaction.

The attenuation is a measure of how much the radio wave is weakened . It is needed to determine the placement and number of the wireless cell components in advance to guarantee a safe radio transmission. Beside this it is very important for the sales to make an accurate offer.
Which factors have to be taken into account for safe planning?

2.1 Theoretical

Field attenuation

The spreading of electromagnetic at frequencies above 30 MHz is like light beams. If a light beam hits an object's surface, it is illuminated with the strength E. With increasing (doubling) of the distance the light beam has to lighten a surface which is four times as big as the original surface. Therefore the illuminate strength decreases proportional to the surface increase i.e. to a quarter of the original strength E.

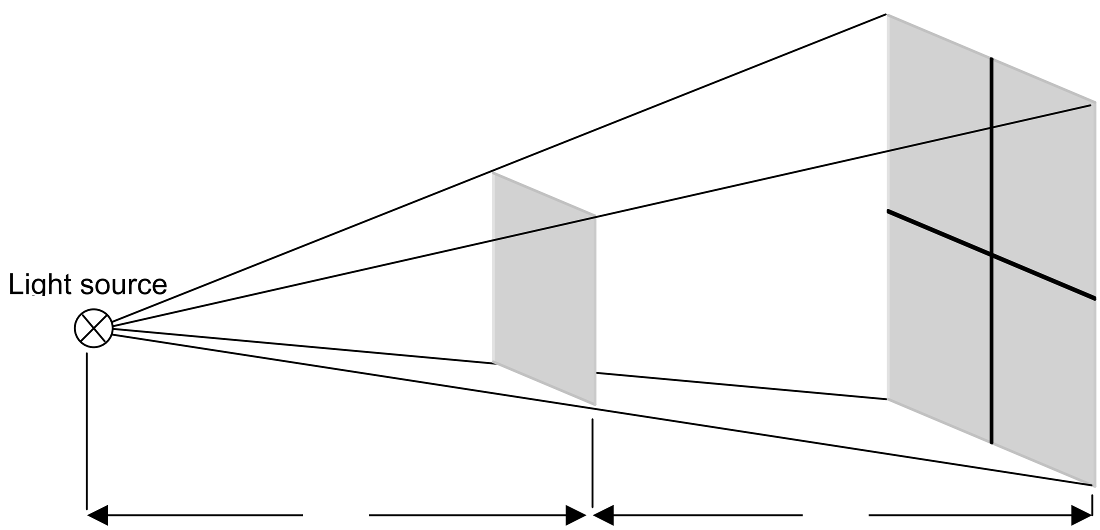

Figure 2.1: Relation light strength to distance

The behaviour of radio waves is quite similar.
One of a radio signals features which differs from sun light is its coherence (coherent = waves of one wavelength in phase). Sunlight (incoherent) runs without coupling in all directions form it’s source.

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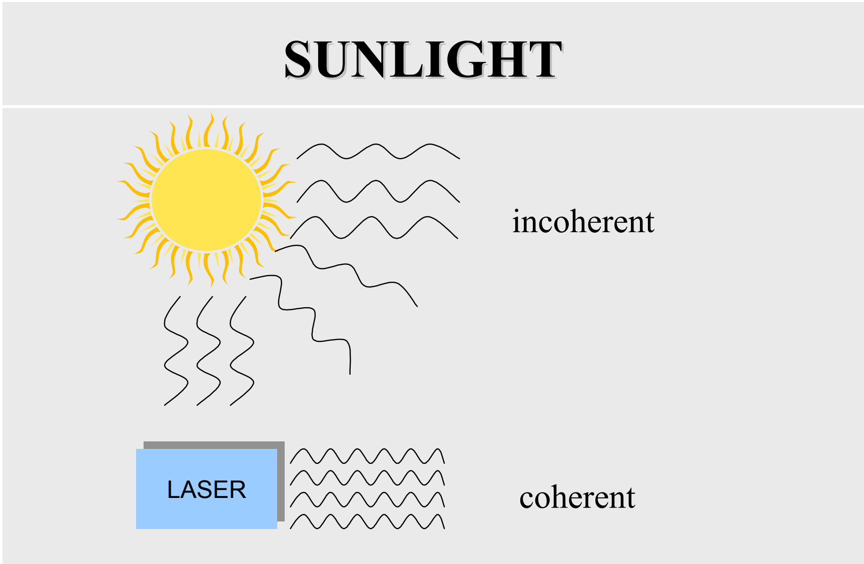
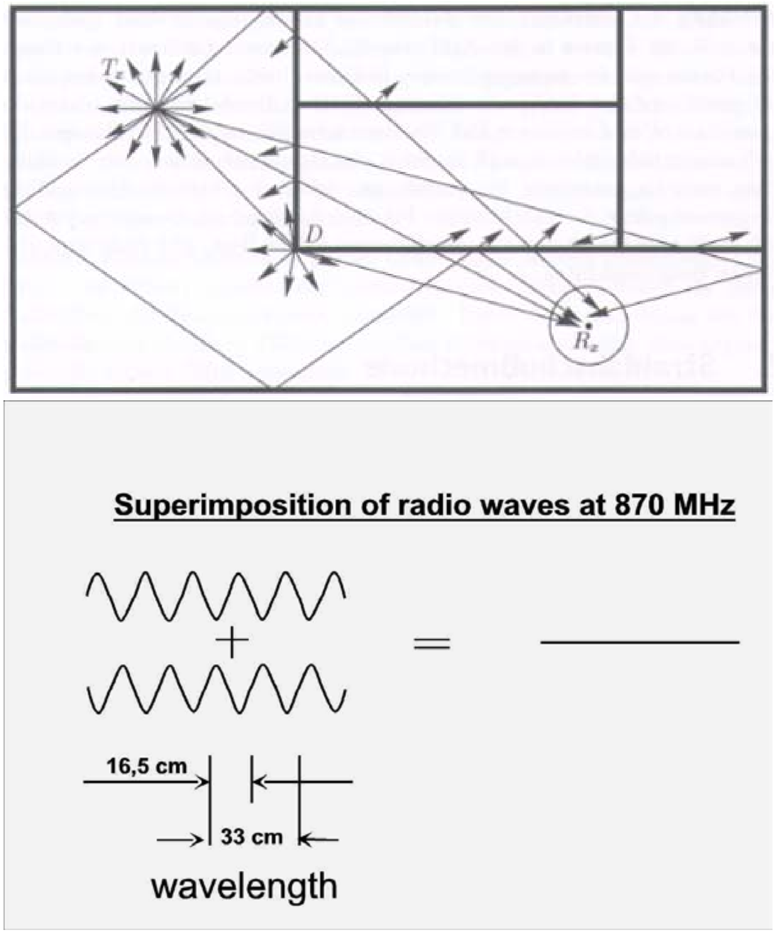


Figure 2.2: Coherent and incoherent light.

Reflection

When like in the algebra, several vectors meet together one point the resulting vector is the sum of all. Depending on the vector orientation vectors are added or subtracted (sun light beams always amplify each other, e.g. switching on of two lamps). In the worst case the vectors subtract from each other and the resulting vector is zero (which is called fading).

In this case no signal can be received on the radio wave.



The sending of radio waves is always spherical around the sender (Tz).
At every spherical obstacle we get again spherical reflections (D).
Therefore the amount of radiowaves which hit the receiver (Rz) have a variety of strength and orientation.
The resulting signal is the sum of them.

Figure 2.3: Wave reflection inside buildings

It's hard to give a prediction inside buildings with its large amount of vector reflections.

There are further ways to calculate the range using computers. These models take account of other influences which have an impact on the transmission of radio waves. Some computer programs use a combination of the beam analysis method and the reflection method.

Putting empirical collected data in a data sheet together we get:

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Relation of field strength and distance

- **Outdoors:**
- Field strength ≃ $1/r^2$
- Double distance: Reduction of ≃ 6dB
- **Indoors:**
- Field strength ≃ 1/r5
- Double distance: Reduction of ≃ 16dB

Attenuation = f (distance) *Indoor examples*

Distance [m]	40	30	25	20	15	10	5
Attenuation [dB]	90	83	79	74	67	57	40

Figure 2.4: Relation of field strength and distance

By the rule of thumb we can calculate that in an outdoor environment with every doubling of the distance between transmitter and receiver we get an attenuation increase of 6 dB. In an indoor environment it is 16 dB.

Obstacles

When radio beams hit an obstacle which prevent the direct way to the receiver two things can happen. Depending on the thickness and material the beam gets either reflected or gets through the material or both.

Unfortunately the relative permitivity is in most cases unknown. Therefore the best way to insert the right values is to take empirically developed attenuation figures.

SIEMENS empirically developed attenuation values for building materials can be found in the next table:

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Relation of attenuation and material

• Room separator	• very low < 1 dB
• Brick, concrete dry	• low ≃ 6 dB
• Sandstone	• moderate ≃ 10dB
• Wood wall	• moderate ≃ 10dB
• Brick wet	• moderate ≃ 10dB
• Plaster plates coated	• moderate / high ≃ 15dB
• Reinforced concrete	• high ≃ 30dB
• Heavy wet brick wall	• very high > 40dB

Figure 2.5: Relation of attenuation and materials

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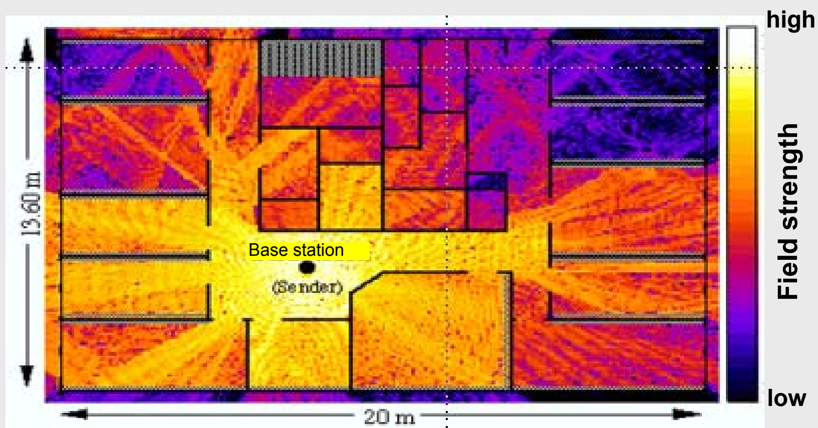
Spread of radio waves within a building



• The wireless communication between gateway and radio detector is based on the effect of omnidirectional radiation.

Figure 2.6: Spread of radio waves within a building

2.2 Practical

As we can see in the above picture the direct way has mostly the highest field strength. In areas where reflection of the radio wave is needed the resulting field strength is different in every room depending on addition and subtraction of the field strength vectors.

Combination method by using the computer

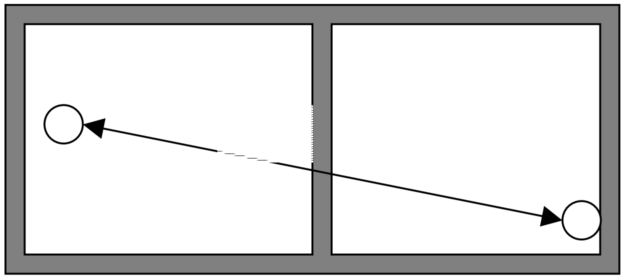
A common way to do the calculation is by using a computer.
The method which is used is called combination method, because it combines the beam analysis method and the reflection method. Both methods have advantages and disadvantages, the combination of both delivers an acceptable result.
Unfortunately the calculation with a computer is currently very time intensive and only possible with high performing computers. The procedures allows the definition of the obstacle material through which the beam has to go through. All insertions of information into the computer need much time.

Attenuation addition method

A way to calculate the attenuation inside of buildings quite simply is the addition of empirical developed single attenuation factors (just distances and obstacles and neglecting the reflection).
This is quite an easy method for every layman to calculate the maximum distance between transmitter and receiver where just a few environment factors have to be taken into account.

Principle:
The difficulties for the proper methology are the right definition of the material which the radio wave has to go through when the direct way is disturbed, and the calculation of the distance between transmitter and receiver or the reflection path between both.
As seen in the previous chapter table 2.4 and 2.5 give the empirical developed overview.
Finally all numbers are added up to the total amount of attenuation.

Example:



Distance:	20m	74 dB
Obstacle:	concrete dry	6 dB
Amount:		80 dB

The disadvantage of this method is that the reflections are not included but it gives a suitable start for making a sales offer and doing the project.

In cases of uncertainty a measurement of the range of a radio cell is imperative. This has also to be done at new installations to guarantee customer satisfaction.

3 Handling of radio frequency fading

As described in the previous chapters the reason for fading is that the resulting vector is zero therefore no signal can be received.

When watching the radio reception over a whole day we find strong deviations because of changing reflection circumstances inside the rooms.

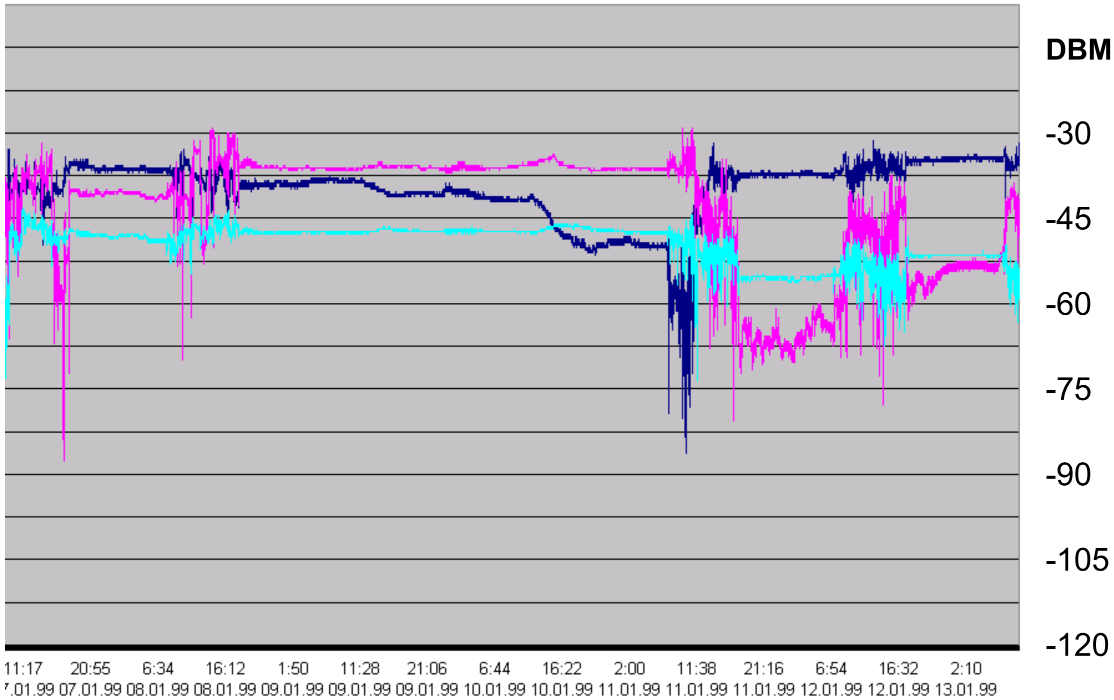


Figure 3.1: Transmission quality of a radio cell watched over a whole week. The reasons for the differences in reception quality are the movements inside the building and therefore changes of the reflections. (tests with just a single hand covering of the radio module show a disturbance of the signal).

How can a radio system avoid this variation in reception?

3.1 Aerial diversity

One solution to avoid this is to equip the radio module with two aerial which are orthogonally oriented to each other. Due to the different vector orientation the module can take the antenna which has the best reception of the signal.

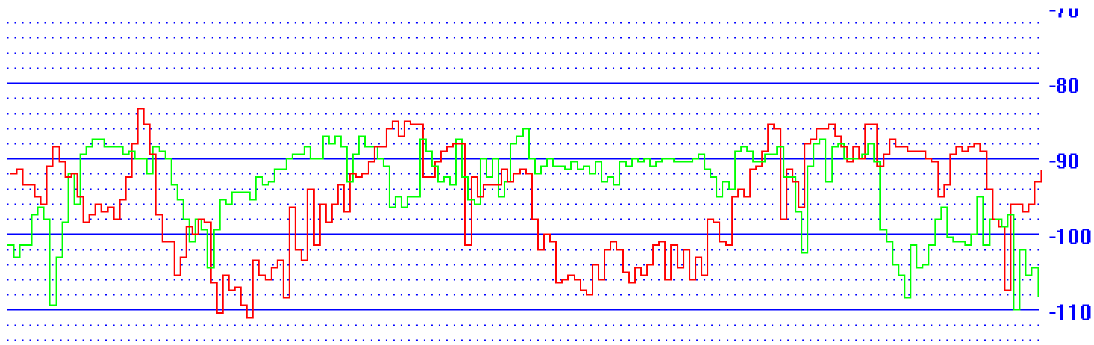


Figure 3.2: Transmission difference with two antennas

(e.g. We can see similarities in our daily life, with our ferrite-rod aerial radio. To get the best reception we rotate the ferrite-rod (orientation) until the radio receives best.)

3.2 Channel switching

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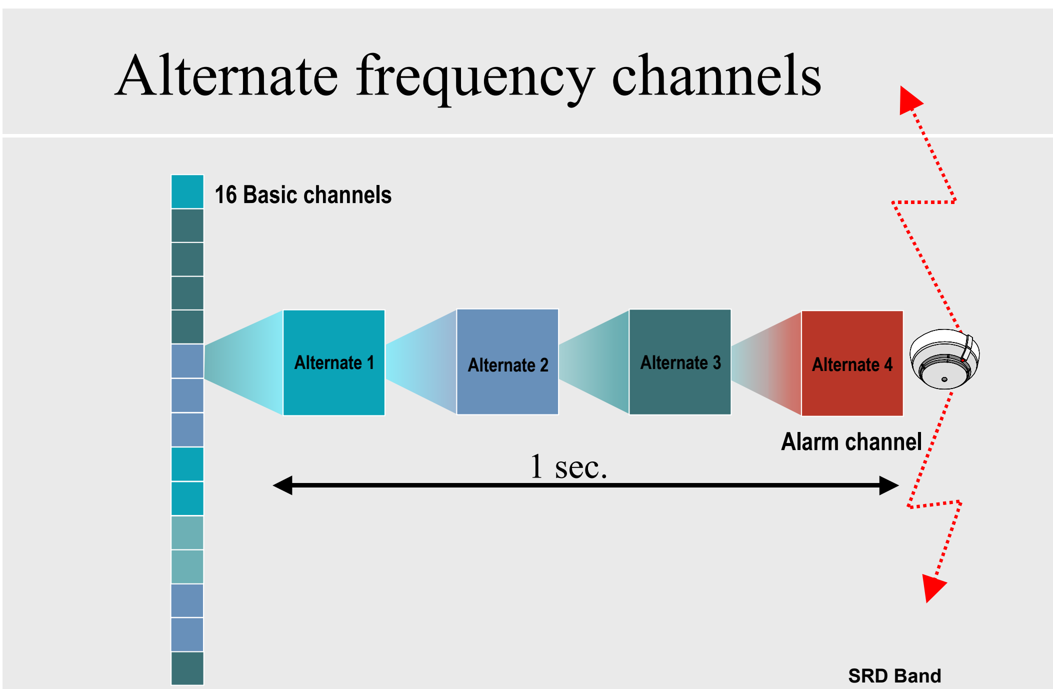

Figure 3.3: Channel switching changing the wave length through changing the frequency.

Another way to avoid short-term reception loss is to change the frequency. This has an impact on the wavelength and the sum of vectors between transmitter and receiver.

*This can be achieved with SIGMASPACE/ TeleRex in a maximum of four times at fixed preprogrammed channels.

3.3 Bypass of information

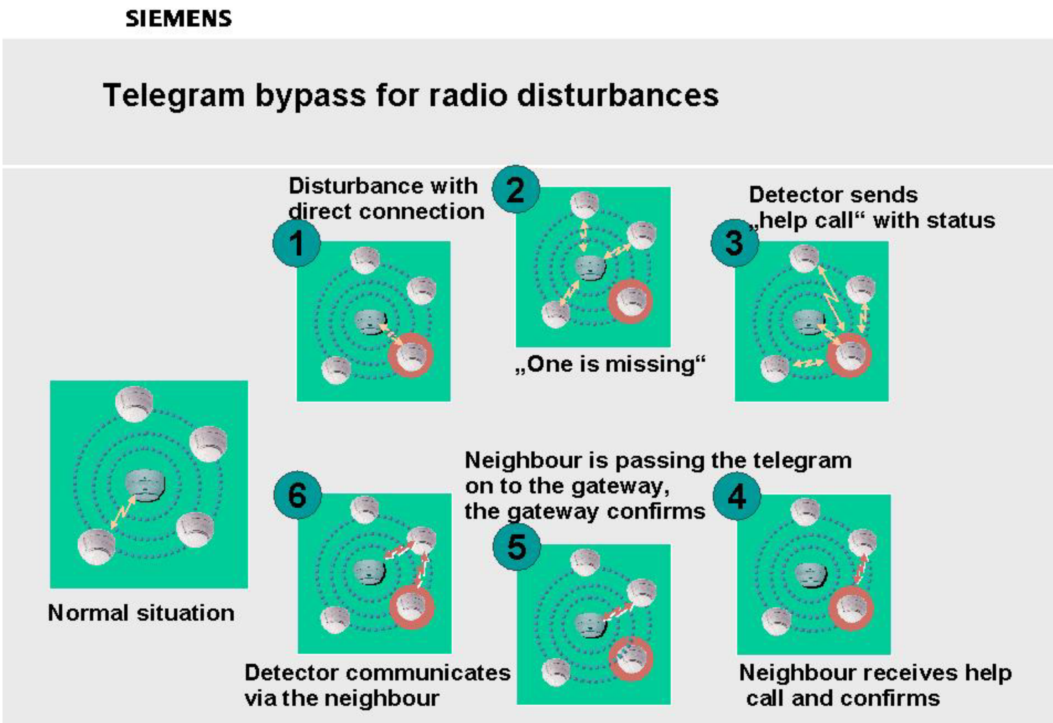

Figure 3.4: Bypass of information

In cases where the transmission from transmitter to receiver is disturbed a technique is to bypass the message via a neighbour radio module and use this as a repeater. The above picture explains how this can work.

*With all these procedures installed in our wireless system SIGMASPACE/TeleRex we have achieved a very high transmission quality. Beside that, disturbances are detected within 100 seconds!

4 Conclusion

Many challenges are testing the progress of modern wireless systems in the building technology infrastructure. Only when the technique dominates totally can it replace wired systems in the future.

This presentation has shown how at SIEMENS these challenges are accepted. We are looking to a sound future of wireless building technology systems.

APPENDIX

Application SIGMASPACE/TeleRex

All building danger alarms as defined under DIN VDE 0833 and a range of additional technical information can be displayed and processed with one system, the SIEMENS SIGMASYS/AlgoRex danger alarm system.

To enhance the flexibility and suitability characteristics of SIGMASYS/AlgoRex, SIEMENS developed SIGMASPACE/TeleRex, a wireless detector system which is integrated into SIGMASYS/AlgoRex. The products allow SIGMASYS/AlgoRex to protect each individual customer's building and keeps pace with the customer's changing environment and requirements.

SIGMASYS hazard detection equipment is able now to keep pace with every customer requirement through the simplest and quickest of system extensions with SIGMASPACE/TeleRex detectors.

The advantages of SIEMENS' wireless system in a nutshell:

- installation neatness – through wireless connection
- flexibility– through use of the most modern radio technology
- functional security- through two patented disturbance handling procedures
- detection reliability – through SIEMENS' 1st class detector experience
- profitability– through simple installation and long battery life
- automation – through automatic radio system configuration

As an example how a typical configuration of SIGAMSYS/AlgoRex with SIGMASPACE/TeleRex can look, see below picture.

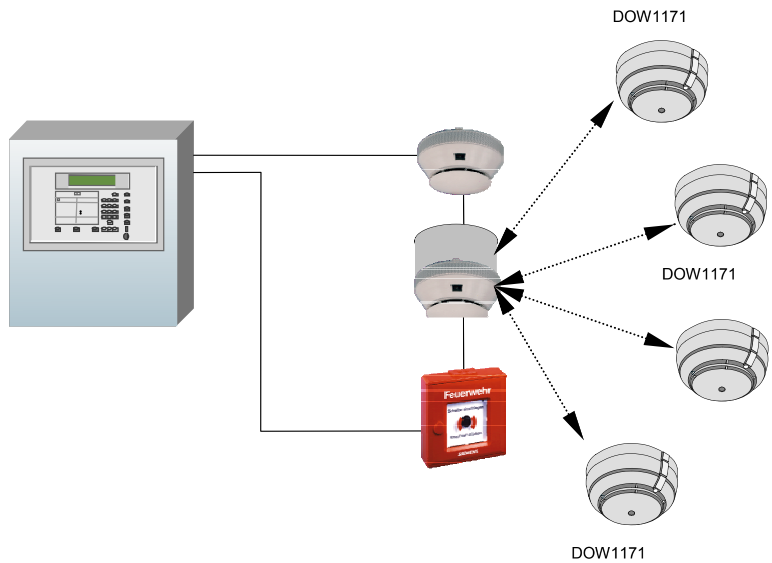

Figure 5.1: Typical configuration SIGAMSYS/AlgoRex with SIGMASPACE/TeleRex

As can be seen in figure 5.1. the SIGMASYS/AlgoRex control unit is wired connected to the detector and the call point. In the middle we see the SIGMASPACE/TeleRex, which is the interface between wired and wireless technology.. The gateway is the master of every radio cell. SIGMASPACE/TeleRex uses wired and wireless technology it is called a hybrid system.

Features

Only approved (VdS EN 54-7) hybrid system in the SRD band with text alarm location message.

Transmission power:	5mW
Frequency:	870MHz
Attenuation budget:	115dB
Wireless distance:	approx. 40m in buildings